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MORTALITY PATTERNS AMONG EMBALMERS

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In view of recent findings of nasal cancer in rats exposed to formaldehyde vapors, we investigated the proportionate mortality experience of embalmers licensed to practice in New York State. Mortality was significantly elevated for cancers of the skin and colon and for arteriosclerotic heart disease, whereas significant deficits were seen in mortality from respiratory diseases and accidents. Respiratory cancer mortality was not excessive and no deaths were attributed to nasal cancer. Mortality was significantly elevated for cancers of the skin, kidney, and brain among those licensed only as embalmers, whereas mortality patterns were unremarkable among those licensed also as funeral directors (and presumably less exposed to formaldehyde). These preliminary results indicate the need for occupational cohort studies to clarify the carcinogenic potential of formaldehyde.

Concern over the health effects of formaldehyde exposure was raised by preliminary results of an inhalation study by the Chemical Industry Institute of Toxicology in which rats exposed to 14.3 ppm formaldehyde vapors developed squamous-cell carcinomas of the nasal cavity (Kerns *et al.*, 1983). Subsequently, rats exposed to 5.6 ppm and mice to 14.3 ppm also developed nasal cancers (Battelle Columbus Laboratories, 1981). These findings were supported by studies at New York University in which inhalation of formaldehyde alone or in combination with hydrogen chloride induced nasal cancer in rats (Albert *et al.*, 1982). These reports were especially worrisome in view of the widespread exposures of workers and segments of the general population to formaldehyde, particularly from indoor pollution resulting from the use of this agent in particle-board, insulation material, and textile products.

In humans, formaldehyde irritates the eyes, skin and respiratory system (National Institute for Occupational Safety and Health, 1976), but few clinical or epidemiologic studies have evaluated long-term effects of exposure. A cohort mortality study of British pathologists and medical laboratory technicians noted an excess of lymphatic and hematopoietic neoplasms among pathologists but not technicians (Harrington and Shannon, 1975). At the Danish Cancer Registry, no association was found between cancers of the nasal passages and lung and employment in medical specialties such as anatomy and pathology that may involve considerable exposure to formaldehyde (Jensen, 1980; Jensen and Anderson, 1982). A proportionate mortality study of 136 formaldehyde production workers showed no unusual patterns compared with the US general population, county population, or unexposed workers in the same plant (Marsh, 1983). A cohort study of 2,026 workers employed in the manufacture of formaldehyde showed some excess of deaths, although based on small numbers, from cancers of the prostate and brain and lymphoma. Mortality from prostate cancer was significantly high among those employed for 20 or more years (Wong, 1983).

Since the turn of the century, formaldehyde has been the main preservative in commercial embalming fluids (Champion Company, 1966). A survey of six funeral homes revealed airborne formaldehyde levels of up to 5.26 ppm, with average concentrations of 0.25-1.39 ppm. Paraformaldehyde particles in formaldehyde vapors were small enough to be deposited in the lungs (Kerfoot and Mooney, 1975). A survey of a mortuary science college by the National Institute for Occupational Safety and Health (1980) reported that the airborne formaldehyde concentrations ranged from 0.20 to 0.91 ppm, but exceeded 3.0 ppm in two samples when the ventilation system was inoperative.

This proportionate mortality study compares the causes of death among embalmers with those of the general population in a preliminary search for unusual mortality patterns that might be related to formaldehyde exposure.

MATERIAL AND METHODS

State health departments were surveyed to determine whether sufficient licensure records existed to establish a cohort of embalmers. No state contacted retained the records necessary for a retrospective cohort study. The Bureau of Funeral Directing and Embalming in the New York State Department of Health, however, maintained a file on deceased embalmers, so it was possible to examine the proportions of deaths due to specific causes. The Bureau was usually notified of the death of a registrant when a license renewal was returned to the office by a relative. In the past, the Bureau offered separate licenses for embalming and for funeral directing (*i.e.*, management of a funeral home). A qualified individual could apply for one license or both, but could not combine the tasks of embalming and funeral directing without having both licenses. In 1947, however, the Bureau began to issue one license valid for both tasks. Since exposure to formaldehyde was the variable of interest, deaths among persons who held only a funeral director's license were not included.

The study group consists of all embalmers licensed to practice in New York between 1902 and 1980, and known to have died between 1925 and 1980. Study subjects were identified through two Bureau data sources: (1) Registration files of recently deceased embalmers, providing the decedent's name, date of birth, first and last years of licensure, last known address, and date of death; and (2) a ledger in which names of all registered embalmers were entered at time of license application. When the office was notified of a death, this fact was frequently recorded in the ledger, providing the decedent's name, first year of licensure, place of residence, and date of death.

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Death certificates were requested for 1,678 embalmers from the appropriate state vital statistics offices and were received for 1,263 of the decedents (75.3%). The death certificate search was more successful for those whose names were identified from the registration file (89.1%) than for those listed only in the ledger (65.7%), since more demographic information was available from the registration file. Underlying cause of death was coded by a nosologist using the rules in effect at time of death and assigning the rubrics of the 8th Revision of the International Classification of Diseases, Adapted (ICDA) (World Health Organization, 1967). Deaths observed among the embalmers were compared to expected numbers computed by applying the age-, race-, and calendar year-specific proportions of deaths for each cause among the US male population to the total number of deaths in the study group by 5-year age and calendar periods (Monson, 1974). Differences between observed (OBS) and expected (EXP) numbers of deaths for each specific cause of death category were summarized as the Proportionate Mortality Ratio (PMR), the ratio of the number of deaths observed to that expected multiplied by 100. The statistical significance of each ratio was tested by a chi-square test with one degree of freedom (Mantel and Haenszel, 1969). Proportionate Cancer Mortality Ratios (PCMR's) were also computed utilizing the total number of cancer deaths as the denominator for calculating the expected number of deaths for each cancer site (Monson, 1974). With the exception of comparisons by latency period, age at first license, and type of license, PMR's and PCMR's were not presented when both the observed and expected numbers of deaths were less than five.

It was not possible to measure length of employment or length of licensure, since year of last license was not available for decedents who were listed only in the ledger. As an alternative, length of time from first license to death was used to approximate length of exposure.

RESULTS

There were 1,132 (89.6%) white men and 79 (6.3%) non-white men in the study group. Forty-two men (3.3%) whose race was unknown and ten women were not included in the detailed analysis. Their mortality patterns, examined separately, were not unusual. The following results refer to white male embalmers except where indicated.

Table I presents the age and calendar year distribution of embalmers at the time of death. Fifty per cent died before age 65. This relatively young age distribution is probably related to the method by which deaths were ascertained. Ninety-five per cent of the embalmers whose year of last licensure was known died within one year of license termination. The median birth-year for those in the study group was 1902 and the median year of initial license was 1931.

Table II shows the mortality experience for white male embalmers according to major causes of death. Mortality from all malignant neoplasms combined was elevated (PMR=111), but not significantly. There was a significant excess of deaths from arteriosclerotic heart disease (PMR=112) and a non-significant excess of deaths from cirrhosis of the liver (PMR=133). Mortality from diseases of the respiratory system was significantly lower than expected (PMR=77), particularly for pneumonia (PMR=64) and emphysema (PMR=67). Mortality from accidental deaths was also significantly low (PMR=49).

The distribution of malignant neoplasms among white male embalmers is shown in Table III. Mortality from cancer of the oral cavity and pharynx was close to that expected, with no deaths from cancer of the nasopharynx. The number of deaths from digestive tract cancers was close to that expected, although there was a significant excess of colon cancer (29 deaths vs. 20.3 expected) and a non-significant deficit of rectal cancer. Respiratory cancer mortality was unremarkable, and no deaths were ascribed to nasal cancer (although the expected value was only 0.50). Mortality from skin cancer was significantly elevated (8 deaths vs. 3.6 expected); four of the eight cases were malignant melanoma (PMR=202), three were squamous-cell carcinoma, and one was unspecified. Mortality was slightly elevated for kidney cancer (8 deaths vs. 5.4 expected), leukemia (12 deaths vs. 8.5 expected), and cancer of the brain and nervous system (9 deaths vs. 5.8 expected). The cell types of leukemia reported on the death certificates were: 6 myeloid (5 acute and 1 unspecified) vs. 4.1 expected, 1 acute monocytic vs. 3 expected, 4 lymphatic (2 chronic and 2 unspecified) vs. 2.6 expected, and 1 acute leukemia

TABLE I – DISTRIBUTION OF DEATHS AMONG WHITE MALE EMBALMERS BY AGE AND CALENDAR YEAR AT DEATH

Age at death	1925-54	1955-59	1960-64	1965-69	1970-74	1975-80	All calendar years	Per cent
20-39	6	4	7	6	5	5	33	2.9
40-44	6	12	5	7	6	9	48	4.2
45-49	12	9	12	7	9	10	61	5.4
50-54	15	24	7	18	20	16	102	9.0
55-59	19	20	15	40	29	33	157	13.9
60-64	19	25	22	24	36	32	162	14.3
65-69	17	27	18	37	30	50	186	16.4
70-74	13	9	23	32	36	45	163	14.4
75-79	6	9	10	23	32	30	115	10.2
80+	4	12	6	6	35	38	105	9.3
All age groups	117	151	125	200	238	301	1132	
Per cent	10.3	13.3	11.0	17.7	21.0	26.6		

TABLE II – NUMBERS OF DEATHS AND PROPORTIONATE MORTALITY RATIOS (PMRs) AMONG WHITE MALE EMBALMERS, BY CAUSE OF DEATH

Cause of death (8th revision, ICDA)	Numbers of deaths		PMR
	OBS	EXP	
All malignant neoplasms (140-209)	243	218.9	111
Circulatory system (390-458)	654	622.4	105
Arteriosclerotic heart disease (410-414)	481	430.7	112[1]
Cerebrovascular disease (430-438)	94	88.9	106
Respiratory system (460-519)	52	67.9	77[1]
Pneumonia (480-486)	16	25.2	64
Emphysema (492)	12	17.9	67
Digestive system (520-577)	60	52.5	114
Gastric and duodenal ulcers (531, 532)	8	8.6	94
Cirrhosis of liver (571)	34	25.5	133
External causes (800-999)	52	85.2	61[1]
Accidents (800-949)	28	57.3	49[1]
Suicide (950-959)	21	21.1	99
Other causes	71	85.1	83
All causes of death	1132	1132.0	100

[1] $p < 0.05$

NOS vs. 1.5 expected. The reported types of brain cancer were 6 glioblastomas (67%), 2 astrocytomas (22%), and 1 carcinoma (11%). In the State of Connecticut, 52.3% of the incident cases during the years 1935-64 were glioblastoma, 18.0% were meningioma, 12.1% were astrocytoma, and other histologic types comprised 17.6% of the cases (Schoenberg *et al.*, 1976). The pattern for PCMR's was similar to PMR's with slight excesses for cancers of the colon, skin, kidney, and brain and deficits for cancers of the stomach and rectum.

Among the 79 non-white men, mortality from all malignant neoplasms combined was elevated (20 deaths vs. 14.5 expected). There was significantly high mortality from cancers of the larynx and lymphatic-hematopoietic system, with only two and three deaths observed, respectively. Mortality from arteriosclerotic heart disease was significantly high (33 deaths vs. 21.3 expected). Deaths from diseases of the respiratory system and from external causes were lower than expected (1 death vs. 4.8 expected for both causes).

The PMR's for selected cancer sites among white males were examined by "latency period", defined as the length of time from first license to death (Table IV). Since most embalmers died while licensed, the length of licensure is assumed to be synonymous with

TABLE III – NUMBERS OF DEATHS FROM MALIGNANT NEOPLASMS WITH PROPORTIONATE MORTALITY RATIOS (PMRs) AND PROPORTIONATE CANCER MORTALITY RATIOS (PCMRs), AMONG WHITE MALE EMBALMERS

Cause of death (8th revision, ICDA)	Numbers of deaths		PMR	PCMR
	OBS	EXP		
All malignant neoplasms (140-209)	243	218.9	111	100
Buccal cavity and pharynx (140-149)	8	7.1	113	103
Digestive organs and peritoneum (150-159)	68	65.2	104	89
Esophagus (150)	5	5.3	95	88
Stomach (151)	12	13.4	90	71
Colon (153)	29	20.3	143[1]	130
Rectum (154)	3	7.7	39	32[1]
Liver and gall-bladder (155-156)	5	4.7	106	119
Pancreas (157)	13	12.3	105	95
Respiratory system (160-163)	74	70.7	105	109
Larynx (161)	2	3.4		
Lung and pleura (162, 163)	72	66.8	108	111[3]
Skin (172, 173)	8	3.6	221[1]	188
Prostate (185)	15	16.4	91	81
Bladder (188)	7	7.3	96	85
Kidney (189)	8	5.4	150	142
Brain and central nervous system (191, 192)	9	5.8	156	138
Lymphatic and hematopoietic system (200-209)	25	20.6	121	—[2]
Lymphosarcoma and reticulosarcoma (200)	5	4.7	108	82
Hodgkin's disease (201)	2	2.3		
Other lymphatic cancers (202, 203)	6	4.9	123	—[2]
Leukemia (204-207)	12	8.5	140	119
Other cancers	21	16.8	125	—[2]

[1] $p < 0.05$. – [2] PCMR's could not be calculated for these sites due to limitations in the computer program used – [3] PCMR for cancer of lung, based on 70 deaths (2 deaths were attributed to pleural cancers).

TABLE IV – NUMBERS OF DEATHS AND PROPORTIONATE MORTALITY RATIOS (PMRs) FOR SELECTED MALIGNANT NEOPLASMS AMONG WHITE MALE EMBALMERS, BY LATENCY PERIOD

Cause of death (8th revision, ICDA)	Latency period[1]					
	<35 years (n = 606)			35+ years (n = 526)		
	OBS	EXP	PMR	OBS	EXP	PMR
All malignant neoplasms (140-209)	123	113.2	109	120	105.8	113
Respiratory system (160-163)	39	36.1	108	35	34.7	101
Skin (172, 173)	4	2.3	173	4	1.3	308[2]
Kidney (189)	6	3.0	201	2	2.4	85
Brain and central nervous system (191, 192)	6	4.0	150	3	1.8	169
Lymphatic and hematopoietic system (200-209)	14	11.6	121	11	9.1	121

[1]Defined as length of time from first license to death. – [2]$p < 0.05$.

latency period. Although the numbers of deaths were small, the proportion dying from skin cancer was greater among those licensed for 35 or more years (4 deaths vs. 1.3 expected) than among those licensed for less than 35 years (4 deaths vs. 2.3 expected). Cancers of the brain and lymphatic-hematopoietic system were also slightly elevated in both latency groups. The elevated PMR for kidney cancer was limited to embalmers licensed for less than 35 years.

Mortality patterns were examined separately for persons licensed only as embalmers and for those who held licenses for both embalming and funeral directing. We assumed that persons licensed only as embalmers experienced a greater cumulative exposure to formaldehyde than did embalmers who were also funeral directors. As shown in Table VI, the PMR's for cancers of the skin, kidney and brain were significantly elevated for those licensed only as embalmers,

TABLE V – NUMBERS OF DEATHS AND PROPORTIONATE MORTALITY RATIOS (PMRs) FOR SELECTED MALIGNANT NEOPLASMS AMONG WHITE MALE EMBALMERS, BY AGE AT FIRST LICENSE

Cause of death (8th revision, ICDA)	Age at first license					
	<30 years (n = 665)			30+ years (n = 467)		
	OBS	EXP	PMR	OBS	EXP	PMR
All malignant neoplasms (140-209)	153	133.4	115	90	85.5	105
Respiratory system (160-163)	50	46.1	108	24	24.6	97
Skin (172, 173)	3	2.3	129	5	1.3	387[1]
Kidney (189)	4	3.4	118	4	2.0	204
Brain and central nervous system (191, 192)	4	4.1	98	5	1.7	294[1]
Lymphatic and hematopoietic system (200-209)	18	13.1	138	7	7.6	93

[1]$p < 0.05$.

Mortality by age at first license is shown in Table V. A significant excess mortality due to skin and brain cancers was seen among those who began to practice embalming at age 30 or later.

while no unusual patterns were observed among those who held both licenses. The difference in year of death between the two groups results from the Bureau's practice since 1947 of issuing one license

TABLE VI – NUMBERS OF DEATHS AND PROPORTIONATE MORTALITY RATIOS (PMRs) FOR MALIGNANT NEOPLASMS AMONG WHITE MALE EMBALMERS, BY TYPE OF LICENSE

Cause of death (8th revision, ICDA)	Type of license					
	Embalmer only (n = 546)			Both embalmer and funeral director (n = 586)		
	OBS	EXP	PMR	OBS	EXP	PMR
All malignant neoplasms (140-209)	105	99.2	106	138	119.8	115
Buccal cavity and pharynx (140-149)	7	3.5	201	1	3.6	28
Digestive organs and peritoneum (150-159)	26	33.5	78	42	31.7	133
Respiratory system (160-163)	27	28.6	94	47	42.1	112
Skin (172, 173)	5	1.5	326[1]	3	2.1	144
Prostate (185)	6	7.3	83	9	9.1	99
Bladder (188)	2	3.5	57	5	3.8	132
Kidney (189)	6	2.4	247[1]	2	2.9	69
Brain and central nervous system (191, 192)	6	2.6	234[1]	3	3.2	93
Lymphatic and hematopoietic system (200-209)	9	9.1	99	16	11.5	139
Average age at death		63.3			64.4	
Average year of death		1960.8			1974.2	

[1]$p < 0.05$.

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which covers both funeral directing and embalming. Mortality among those licensed only as embalmers was examined by latency period. Brain cancer mortality was significantly elevated among those licensed for less than 35 years (5 deaths vs. 1.9 expected) and skin cancer mortality was significantly elevated among those licensed for 35 or more years (3 deaths vs. 0.5 expected).

DISCUSSION

Using the proportionate mortality approach, this study shows that embalmers experienced a slightly elevated mortality from cancer, a significant excess of arteriosclerotic heart disease, and a significant deficit of respiratory diseases and accidental deaths. The site-specific patterns of cancer mortality were not sufficient to implicate formaldehyde as a carcinogen, but some variations were intriguing. Skin cancer mortality (including melanoma) was significantly elevated, with a greater excess observed among those licensed for more than 35 years and those who began employment at age 30 or later. Also significantly elevated was the proportionate mortality from skin, kidney and brain cancers among those who were licensed only as embalmers. There was, however, no excess mortality from cancers of the respiratory tract including the nasal passages. This is noteworthy in view of evidence that inhalation of formaldehyde induces squamous-cell carcinomas of the nasal cavity in rats (Kerns *et al.*, 1983). The mortality patterns in our study, however, suggest that further investigation of the carcinogenic effects of formaldehyde should extend beyond the respiratory system.

This study was intended as a preliminary epidemiologic study of the chronic effects of formaldehyde exposure and has several deficiencies. The study group was not exposed solely to formaldehyde but to embalming fluids that contain other chemicals (*e.g.*, tissue moisturizers, antiseptic solutions, dyes, and deodorizers), partly to offset the adverse reactions of formaldehyde (Champion Company, 1966; Kirk-Othmer, 1965). In addition, length-of-employment information was unavailable, the ascertainment of deaths among retirees was incomplete, and the size of the study group may be insufficient to detect elevated risks of rare neoplasms such as nasal cancer. Of special concern are the limitations of the proportionate mortality method, notably the uncertainty that an excess proportion of deaths from a specific cause reflects a real elevation in mortality or a deficit in the proportion of deaths from other causes (Decoufle *et al.*, 1980). Nonetheless, our findings and other preliminary studies (Harrington and Shannon, 1975; Marsh, 1983; and Wong, 1983) indicate that cohort studies of several groups of formaldehyde-exposed workers are needed to further assess the carcinogenic risks of this widely used compound.

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